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by

Piotr Dabrowski

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FTD-ID(RS)T-1860-78

EDITED TRANSLATION

FTD-ID(RS)T-1860-78 21 November 1978

MICROFICHE NR: FTD-78-C-001589

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English pages: 11

Source: Pomiary Automatyka Kontrola, Vol. 23, Nr. 10, 1977, pp. 384-386

Country of origin: Poland
Translated by: SCITRAN
F33657-78-D-0619
Requester: FTD/TQTR
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SEMICONDUCTOR OPTOELECTRONIC SENSORS

by Piotr Dabrowski

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Abstract: The types and properties of optoelectronic sensors consisting of a light emitting diode and phototransistor are described. The domestically made CQ07 BP and CQ 08 BP sensors are described with their basic parameters and the results of some studies. Typical applications and comments concerning the operational conditions are also given.

The semiconducting optoelectronic sensors have been used for several years in control instrumentation. Their advantages are long life, reliability, non-contact and fast switching and the compatibility with TTL elements.

In comparison to the optoisolators, in which there is no access to the light beam, which is the information carrier within the opto-isolator, the principle of operation of optoelectronic sensor is based on such access. Depending on the sensor applications one of the two designs are used. The first one, is the sensor with mechanically interrupted light beam, and the other, the reflection sensor in which the output signal changes depending on the amount of light reflecting from different (as far as shape and reflection coefficient are concerned) surfaces. The basic design principle of these sensors is shown in Fig. 1a and 1b.

The inputs of both sensors are the gallium arsenide light emitting diodes (LED), emitting the near infrared radiation, and the outputs are the silicon phototransistors without the base connection. Often, especially in the reflection sensors in which the optical link is much

weaker, the output consists of photo-darlington or Schmitt trigger with a phototransistor. In both sensors, in addition to the basic ability of mechanical control of the light link, there is possibility of setting the output signal level by changing the LED and phototransistor supply voltage.

The interrupted beam sensors.

The design principle of such a sensor is to place the LED opposite to the phototransistor in a housing with 2 - 3 mm gap between these elements.

These devices have a number of applications, eg:

- position sensors of moving parts in many mechanisms and point switches; a typical application is the breaker in automotive electronic ignitions,

- holes or gap sensors in punched tapes and cards, also in magnetic tapes,

- code readers on transparent taped, LED,

- end-of-tape sensors of cinematographic film

- position sensors of fibers, wires, threads, flowing liquids or liquid level.

The domestically made sensor of this type shown in Fig. 2, has the designation CQ 07 BP and is manufactured[1]) by the Semiconductor experimental Laboratory at the Electronic Technology Institute of NPCP. The electrical parameters are given in Table 1. The sensor contains an epitaxial GaAs diode sealed with lens-shaped epoxy resin, and a planar n-p-n silicon phototransistor without base output, sealed

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1) Orders can be placed with:

in a metal housing with a flat glass window. The semi-angle of beam divergence for the LED is over 70°, and the sensitivity angle for phototransistor is over 80°. To obtain good results therefore, the apertures or slits used with the CQ 07 BP sensor should be larger than 0.5 mm.

The reflection sensor

In the sensor of that type the LED and the phototransistor are placed in the common housing in such a way that their face plates (emission and detection) are on the same side. The housing prevents direct phototransistor illumination by the LED, thus, it will respond only to the radiation reflected from the surface at the front of the sensor. The optical axes of LED and phototransistor can be parallel or cross each other. The reflection sensors are used for position sensing of large elements with only one access side or moving at differing distances from the sensor. One of the typical applications is an universal tachometer head, in which the rotating element has a surface element with different light reflection properties, (eg: polished or painted segment).

The domestically made reflection sensor CQ 08 BP, and the silicon phototransistor, without base connection, encapsulated in the lens shaped epoxy. The radiation divergence angle is about 70°. The type and the distance of the reflecting surface from the sensor (Fig. 4) has a significant influence on the output signal (Fig. 5). The curvature of the reflecting surface has a minimal effect, as long as the curvature radius is larger than 10mm.

Fig. 6 shouw the oscillogram of the output signal obtained from the sensor close to the rotating aluminum wheel, on which one segment was painted black. The pulses were measured across the 100 Ω resistor in the phototransistor collector, and with the U_{cc} = 5V supply voltage. The sensor input was driven with a current I_f - 90 mA. The picture was taken without the use of pulse shaper. As it can be seen, the obtained result is satisfactory, despite the great simplicity of the measuring system. If necessary, one can always use the pulse shaping circuits. The signal fluctuations between pulses as seen as on the picture, are caused by the reflections from uneven surface. In practical applications this effect will always be present, and the circuit design should provide for the adequate separation between signal and noise.

This article is intended as a collection of practical information which could be of interest for the designer. If they would inspire the wide use of CQ 07 BP and CQ 08 BP sensors the author will be very grateful.

The author is grateful to Mr. Adam Liszewski for his careful measurements which were used here.

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Received 6. 6. 1977

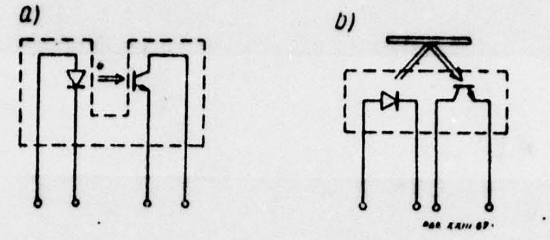

Fig 1. Design principle of optoelectronic sensors:

a) with the interrupted beam, b) reflection sensor

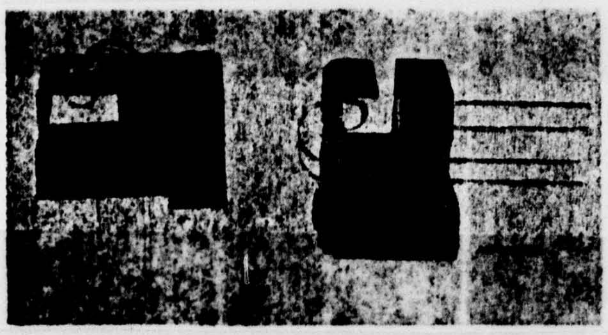

Fig 2. The CQ 07 BP sensor

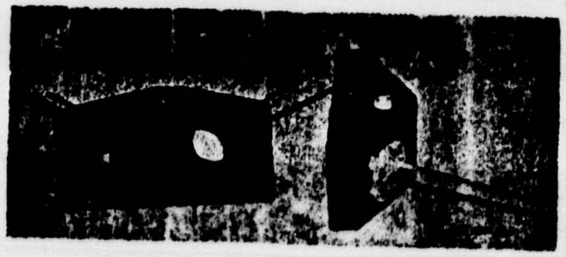

Fig 3. The CQ 06 BP sensor

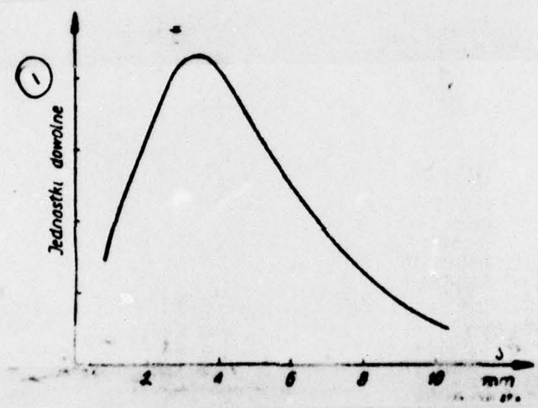

Fig 4. Dependence of the output signal value from CQ 08 BP sensor as a function of distance from uniform reflecting surface . 1 - arbitrary units.

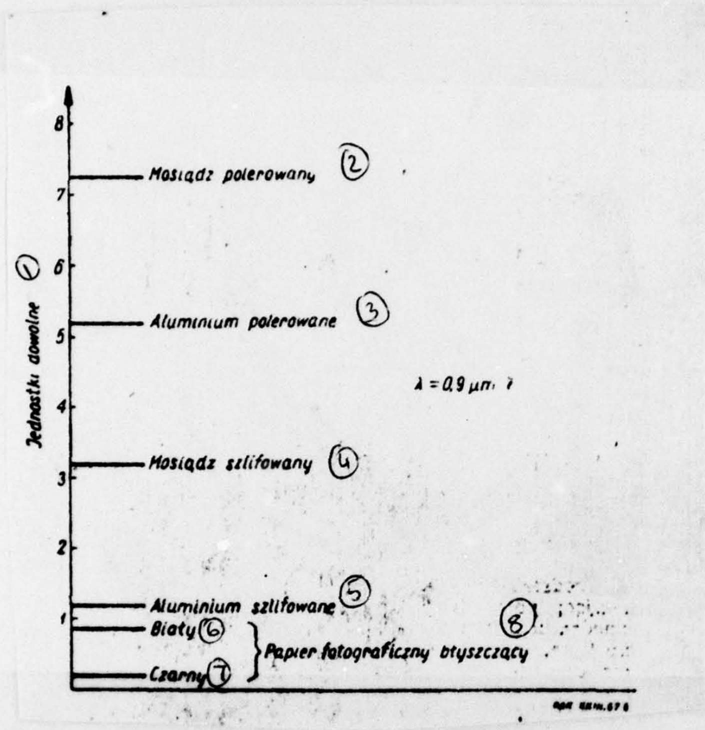

Fig 5. Magnitude of the output signal from CQ D8 BP sensor using different reflecting surface. 1 - arbitrary units, 2 - polished brass, 3 - polished aluminum, 4 - ground brass, 5 - ground aluminum, 6 - white, 7 - black, 8 - photographic paper (glossy).

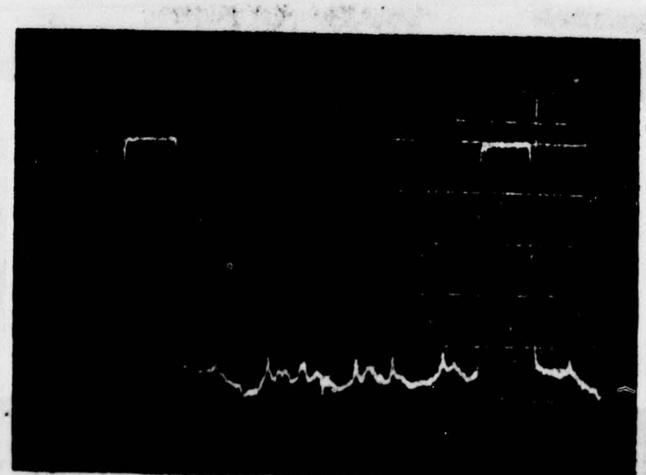

Fig 6. Oscillogram of the CQ 08 8P output using the reflection from rotating wheel.

Dopuszczalne wartości parametrów eksploatacyjnych 1		
	CQ 07 BP	CQ 08 BP
Prąd przewodzenia diody I_F 2	130 mA	150 mA
Napięcie wsteczne diody U_R 3	3 V	3 V
Napięcie kolektor-emiter fototranzystora U_{CE} 4	15 V	15 V
Moc strat fototranzystora P_{fot} 5	10 mW	10 mW
Temperatura pracy 6	+5 do +55°C	−40 do +55°C
Temperatura przechowywania 7	−40 do +70°C	−40 do +70°C
Parametry charakterystyczne przy $t = 25°C$ 8		
Prąd wsteczny diody I_R 9 przy $U_R = 3$ V	0,1 μA	0,1 μA
Napięcie przewodzenia 10 diody U_F przy $I_F = 100$ mA	1,3 V	1,3 V
Prąd ciemny fototranzystora I_{CEO} 11 przy $U_{CE} = 15$ V	20 nA	20 nA
Fotoprąd fototranzystora I_P przy $U_{CE} = 8$ V, 12 $I_F = 100$ mA	I : 2,5 mA II : 4,5 mA	[1]
Czas narastania i opadania impulsu fotoprądu 13 t_r, t_f przy $U_{CE} = 8$ V, $I_{Po} = 2$ mA, $R_L = 100\Omega$	20 μs[2]	20 μs[3]
Wymiary gabarytowe obudowy czujników, 14 mm	10,5 × 18,5 × 17	18 × 8 × 7

[1]) Zależy od rodzaju powierzchni odbijającej (rys. 4 i 5). 15

[2]) Przy impulsowym zasilaniu DEL. 16

[3]) Przy impulsowym zasilaniu DEL oświetlającej bezpośrednio fototranzystor. 17

Table 1

Basic parameters of CQ 07 BP and CQ 08 B sensors.

1 - Max. allowed values, 2 - Forward diode current I_f, 3 - Reverse diode voltage U_r, 4 - Phototransitor collector-emitter voltage U_{cE}, 5 - phototransitor emission power P_{fot}, 6 - Temperature range, 7 - Storage temperature, 8 - Typical parameters @ t = 25 C, 9 - reverse diode current I_r @ U_r = 3V, 10 - Forward diode voltage U_f @ I_f = 100 mA, 11 - phototransistor dark current I_{ceo} @ U_{ce} = 15V, 12 - Phototransistor current I_p @ U_{ce} = 8V, I_f = 100 mA, 13 - Rise and fall time t_r and t_f @ U_{ce} = 8V, I_{po} = 2 mA, R_1 = 100 , 14 - Overall dimensions mm.,

15 - Depends on the Reflecting surface (Fig 4 and 5), 16 - With pulsed LED supply, 17 - With Pulsed supply of LED directly illuminating the phototransistor.

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